

SECTION 16050

BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK

PART 1 - GENERAL

0.1 DESCRIPTION OF WORK

- A.** Work Included: This Section specifies basic materials and methods for electrical work.
- B.** Related Work: Refer to Section 16450-Grounding, for proper installation of components identified in this section. The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Determine interfaces and coordinate electrical work with utility company or the Authority where power source is the Authority's.
 - 2. Determine interfaces and coordinate with work completed, progressing, or to be performed under other sections of these Specifications or by other contractors. Make indicated connections to previously completed work. Where future connections to or extensions of the work are indicated, make safe and convenient provisions for such future connections and extensions.
 - 3. Where indicated, take possession of, maintain, and operate as required any electrical plant and equipment left in place by others. Where indicated, leave temporary and interim electrical work, plant and equipment in place for maintenance and operation by others.

0.2 REFERENCES

- A.** Comply with applicable requirements of the following:
 - 1. National Electrical Code
 - 2. Massachusetts Electrical Code

0.3 SUBMITTALS

- A.** Submit shop drawings for review showing fabricated work being furnished and installed under these Specifications. Submit such drawings prior to fabrication and within ample time to prevent delays in the work.
- B.** Submit verified test results to the Engineer promptly upon completion of test.
- C.** Before installation of the wire and cable, submit the following information for each type and size of wire and cable for review:

1. Manufacturer of the wire and cable.
2. Number and size of strands composing each conductor.
3. Conductor insulation composition and thickness in mils.
4. Average overall diameter of finished wire and cable.
5. Minimum insulation resistance in megohms per 1000 feet at 20°C ambient.
6. Jacket composition (if any) and thickness in mils.
7. Total number of conductors per cable.
8. Shield material (if any) and thickness.
9. Conductor resistance and reactance in ohms per 1000 feet at 20°C ambient.
10. Conductor ampacity at 20°C ambient.

PART 2 - PRODUCTS

0.1 GENERAL REQUIREMENTS

- A.** Furnish all items of the materials, design, sizes, and ratings shown on the Contract Drawings and herein specified.
- B.** Furnish materials and equipment bearing evidence of UL listing where UL standards exist and such product listing is available.
- C.** Methods of fabrication, assembly and installation are optional unless otherwise specifically indicated.
- D.** Provide products that are free from defects impairing performance, durability, or appearance, and of the commercial quality best suited for the purpose shown on the Contract Drawings or specified herein.
- E.** Steel conduit and accessories specified to be zinc coated: Hot-dipped galvanized after fabrication in accordance with ASTM A286.
- F.** Conform to applicable requirements of Insulation Power Cable Engineers' Association (IPCEA).

0.2 RIGID GALVANIZED STEEL CONDUIT AND ACCESSORIES

- A.** Conduit, couplings, elbows, bends, and nipples: ANSI C80.1 and UL 6, with each length bearing manufacturer's stamp and UL label.
- B.** Method used to determine the thickness of zinc coating: The Referee Test included in the appendix to ANSI C80.1.
- C.** Fittings and Accessories:
 1. Galvanized steel or malleable iron, ANSI C80.4.

2. Provide separable watertight hub fittings with a gasket, separate nylon insulated throat and a case hardened locknut.
3. Bushings: Nylon insulated metallic and grounding type.
4. Furnish conduit straps, clamps, and clamp backs made of galvanized malleable iron.

D. PVC Coated Conduit

1. NEMA Standard No. RN1, Coating Type A-40.
2. Thread protectors installed on both ends of conduit for shipment and handling, couplings packaged separately.

E. Almost without exception, in any below grade structures, the MBTA requires the use of RGS conduit.

F. All conduits penetrating floors and ceilings must have brass labels for ease of tracing circuits.

G. Buried conduits cannot have buried pull boxes.

0.3 LIQUID-TIGHT FLEXIBLE METALLIC CONDUIT AND FITTINGS

A. Furnish conduit consisting of a core of flexible galvanized steel with an extruded liquid-tight plastic or neoprene jacket overall. Jacket shall be moisture and oil-proof, capable of conforming to the minimum radius bends of flexible conduit without cracking.

B. Furnish conduits with a continuous copper bonding conductor spiral wound between the convolutions, as required by NEC, and as indicated.

C. Fittings: UL Standard 514, cadmium or zinc-coated.

0.4 PVC ELECTRICAL CONDUIT AND FITTINGS (ONLY FOR OUTDOOR USE)

A. Heavy wall, high impact strength, rigid PVC conforming to the requirements of EPC-40-PVC conduit of NEMA TC2 and fittings for EPC-40-PVC conduit of NEMA TC3.

B. UL listed in accordance with Article 347 of the NEC for underground and exposed use.

C. Flammability rated as self-extinguishing, and having the following minimum properties:

1. Tensile strength, ASTM D638 at 78°F: 6,000 psi.
2. Flexural strength, ASTM D790: 11,000 psi.
3. Compressive strength, ASTM D695: 8,500 psi.
4. Hardness (Durometer D), ASTM D2240: 77.

5. Water absorption, percent maximum, in 24 hours at 72°F. ASTM D570: 0.03.
6. Dielectric strength, volts per mil, ASTM D149: 1,100.
7. Thermal conductivity: 1.3 BTU per square foot per degree F per inch.

0.5 CONDUIT EXPANSION FITTINGS

- A.** Fabricate from material similar to the type of conduit with which they are to be used.
- B.** Include a factory installed packing ring, designed to prevent the entrance of moisture, and a pressure ring.
- C.** Also include a grounding ring or a grounding conductor for metallic expansion couplings.

0.6 MULTIPLE PIPE HANGERS (TRAPEZE TYPE)

- A.** Fabricate of two or more steel hanger rods, a steel horizontal member and all U-bolts, clamps, and other attachments necessary for securing hanger rods and conduits.
- B.** Hanger Rod: Not smaller than 3/8 inch diameter, threaded either full length or for a sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
- C.** Horizontal Member
 1. Standard structural steel shapes such as angles or channels, 1-1/2 by 1-1/2 or 1-5/8 by 1-5/8 inches, 12 gauge, cold-formed, lipped channel, and designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments.
 2. Two or more channels may be welded together to form horizontal members of greater strength than single channels.
 3. Galvanize after fabrication.
- D.** Design
 1. Capable of supporting a load equal to the sum of the weights of the conduits and wires, the weight of the hanger itself, plus 200 pounds.
 2. The stress at the root of the thread of the hanger rods; not more than 9,475 psi at design load.
 3. Size the horizontal member such that the maximum stress will be not more than 12,650 psi at design load.

0.7 INSERTS

- A.** Channel Inserts. Fabricate from not less than 12 gauge steel channel having an overall size of 1-1/2 by 1-1/2 or 1-5/8 by 1-5/8 inches with continuous 7/8 inch wide slot, in lengths as indicated. Galvanize after fabrication.
- B.** Channel Inserts for Embedding in Concrete
 - 1. Fabricate from channels having a solid base.
 - 2. Weld concrete anchors to the channel during fabrication and before coating.
 - 3. Galvanize after fabrication
 - 4. Provide assemblies with a minimum pull-out load rating of 4,500 pounds per linear foot uniformly distributed.
 - 5. Furnish all channel inserts for installation embedded in concrete with the channel interior completely filled with styrofoam to prevent seepage of concrete into the channel during installation.
- C.** Channel Inserts for Surface Mounting
 - 1. Fabricate from channel having 3/8 inch by 3-inch slots on 4-inch centers in the base.
 - 2. Galvanize inserts for surface mounting on concrete surfaces or for installation in damp or wet areas.
- D.** Spot Inserts for Embedding in Concrete
 - 1. Steel, galvanized after fabrication
 - 2. Designed for a maximum loading of 800 pounds with safety factor of three.
 - 3. Knockout openings to accommodate either square or rectangular nuts.

0.8 SURFACE METAL RACEWAYS AND FITTINGS

- A.** ANSI/UL 5 and the NEC.

0.9 OUTLET, JUNCTION AND PULL BOXES

- A.** Conform to NEC Article 370. Electrical boxes shall conform to UL-50, "Standard for Electrical Cabinets and Boxes", and UL-514, "Standard for Electrical Outlet Boxes and Fittings".
- B.** Provide electrical boxes of the material, finish, type and size indicated and required for the location, kind of service, number of wires, and function. Boxes shall have mounting holes retapped for 10-24 machine screws.

- C.** Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used, except that boxes in which or on which no devices or fixtures are to be installed, shall be equipped with flat or raised blank covers as required. All ceiling fixture outlet boxes shall be equipped with 3/8-inch boltless fixture studs.
- D.** Boxes not over 100 cubic inches in size shall be cast. Boxes over 100 cubic inches in size shall conform to the requirements for cabinets.
- E.** Covers: Same thickness as boxes and secured in position by means of No. 10-24 stainless steel machine screws. Arrange covers to be readily and conveniently removed.
- F.** Coat junction boxes inside and outside to prevent oxidation. Where outlet boxes are used as junction boxes they shall be cast aluminum and not be smaller than 4 inches square by 1-1/2 inches deep. Provide such boxes with flat blank covers.
- G.** Outlet Boxes: Cast aluminum, not be smaller than 4 inches square by 2-1/8 inches deep.
- H.** Concealed Switch Boxes: Cast aluminum, not less than 4 inches square by 1-1/2 inches deep for two devices unless otherwise indicated. Provide covers with rectangular openings of proper size and shape. Furnish and install special boxes required to suit the kind of service and location requirements, as indicated, and as may be directed by the Engineer.
- I.** Cast metal boxes shall be of aluminum alloy, with compatible conduit fittings.
- J.** Boxes for exposed switches and receptacles: Cast metal, FS and FD Types.
- K.** Furnish brackets, supports, hangers, fittings, bonding jumpers and all other accessories required.
- L.** Provide neoprene gaskets 1/8 inch thick with boxes subjected to weather, and as directed by the Engineer.
- M.** Grounding. Provide each box to which a lighting fixture or receptacle is to be attached with a grounding terminal.
 - 1. Grounding Terminal: Either a green-colored washer-in-head machine screw not smaller than No. 10-32 in a drilled and tapped hole in the back of the box, or a grounding bushing with green-colored machine screw terminal attached to one of the conduits.
 - 2. Provide suitable grounding terminals in motor connection boxes.
 - 3. Install grounding jumpers as specified in Section 16450 - GROUNDING.
- N.** Junction and pull boxes must be surface mounted and not buried.

0.10 CABLE TRAYS

- A.** General. Provide cable tray systems conforming to the requirements of NEMA VE1, except for modifications indicated. Cable tray system shall be designed to withstand Seismic Zone 3 earthquake.
- B.** Cable Tray System Components: Hot-dipped, galvanized steel with PVC coating; or, stainless steel.
 - 1. Hot-dipped galvanized after fabrication in accordance with ASTM A 386. PVC coating of 20 mils minimum having Shore A durometer hardness of 75.
 - 2. Stainless steel as indicated.
- C.** Dimensions
 - 1. Straight sections and fittings: Inside clear width as indicated, measured between the rails. Overall width not exceeding inside depth by more than 2-1/2 inches. Inside nominal depth: 4 inches. Overall tray depth not exceeding inside depth by more than 3/4 inch.
 - 2. Rung spacing for ladder-type straight sections: 9 inches on centers maximum.
- D.** Fabrication
 - 1. Straight sections and fittings consisting of stiffened channel rungs located between channel-shaped side rails having outward projecting flanges.
 - 2. Straight-section side rails shall have a top flange at least 1-1/4 inches wide and minimum 3/8-inch vertical stiffening lip.
 - 3. Rungs shall be positioned to provide a flat, cable support surface at least 1-1/8 inches wide, excluding corner radii, and shall be 0.060 inch thick. MIG-weld rungs to side rails and clean welds.
- E.** Test Requirements
 - 1. Cable tray system shall be capable of supporting a total cable load of 55 pounds per linear foot on a maximum span of 8 feet with a safety factor of 2 based on the destructive load, regardless of the type of splice plates or type of span, when tested in accordance with load test procedure described in NEMA VE1.
 - 2. Straight sections and fittings shall not permanently deform under a 202 pound static concentrated load applied vertically along a 4-inch length for both of the following conditions:
 - a. Load applied to one side rail of tray section having specified cable load and support spacing. Load shall be applied at midpoint between supports over a splice connection.
 - b. Load applied to one rung of empty tray section having specified support spacing. Load shall be located at midpoint between side rails and supports. Cable tray support shall be capable of

supporting 0.625 of the sum of the total load on both spans adjacent to support with safety factor of 2.

0.11 CABLE TRAY CHANNEL SUPPORTS

- A.** Fabricate from minimum 12 gauge steel channel, 1-5/8-by-1-5/8 inches, with a continuous 7/8-inch wide slot. Hot-dipped galvanized.
- B.** Hardware, Fittings, and Brackets: Zinc or cadmium coated.
- C.** Design assembled supports, fittings, brackets, and hardware to carry the loads shown on the Contract Drawings with a factor of safety of three or greater.
- D.** Supports shall provide at least 1-1/8 inch bearing length for each rail and shall have provision for tray hold-down clamps and fasteners.

0.12 UNDERFLOOR DUCTS, TRENCHES, AND FITTINGS

- A.** Manufacture ducts and trenches from 14 gauge galvanized steel, furnished with a UL listed corrosion-resistant coating.
- B.** Design fittings for use with the duct or trench to form a complete underfloor raceway system.
- C.** Ducts for Power Service: 3-1/8 inches wide by a minimum 1-1/4 inches deep, or 6 inches wide by 1-1/2 inches deep, as indicated, with threaded 2 inch IPS inserts spaced on 2-foot centers.
- D.** Ducts for Low Voltage, Communication, or Signal Use; Six inches wide by 1-1/2 inches deep with 2-inch IPS inserts spaced on 2-inch centers.
- E.** Floor Trenches: 18 inches wide by 4 inches deep with 5/16-inch thick floor plate. Cover plates of maximum length, as indicated.
- F.** Equip inserts with caps and countersunk-head floor marking screws.
- G.** Size junction boxes for underfloor ducts to accommodate the ducts, and finish similar to the duct.
- H.** Provide approximate tile holders of a depth as required for installation of the floor finish.
- I.** Provide service fittings where required, complete with adapters and locking nipples suitable for use with the duct.

0.13 WIRE AND CABLE (600 VOLT)

A. Conductors: Conform to the requirements of the NEC.

1. Feeder and Branch Circuit Conductors: Soft-drawn copper.
2. Control Circuits: Soft-drawn copper.
3. Conductor Sizes: Standard American Wire gauge sizes. Conductors No. 10 and smaller, solid copper; No. 8 and larger, stranded copper.
4. Minimum AWG sizes unless otherwise indicated:
 - a. No. 12 for branch circuits.
 - b. No. 14 for control wire and fixture wire
 - c. No. 16 for low voltage circuit and indication wire.

B. Wire and Cable 600 volts and Below Installed Raceways: Single conductor, NEC type XHHW, conforming to requirements of NEMA WC 7, or THWN.

C. Fixture Wire: Type AF single conductor, rated for 150°C conductor temperature, 300 volts.

D. Color Coding of Conductors

1. Color code supply cables and branch circuit conductors throughout the secondary alternating current wiring system as follows:

Conductor	208/120 Volts	480/277 Volts
Phase A	Black	Orange
Phase B	Blue	Yellow
Phase C	Red	Brown
Neutral	White	Off-White
Ground	Green	Green

2. Color code single-conductor wires as follows:
 - a. 480/277 volt circuits, blue with yellow tracer.
 - b. 120/208 volt circuits, yellow with blue tracer.
3. Branch circuit phase conductors No. 10 and smaller and all neutral and equipment conductors: Solid color insulation or solid color coating.
4. Solid color coatings and tracers: A strongly adherent paint or dye not injurious to the insulation and which will not be obliterated by pulling into a conduit or raceway.
5. On-site coloring of ends of conductor may be permitted by the Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color-coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is non-injurious to the insulation. Colored tape may be used to mark the ends of conductors in lieu of paint or dye.

E. Identification Tags

1. Provide waterproof identification tags of brass, aluminum, plastic, or pressure-sensitive moisture-resistant labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms and at all terminations of cable or wire.
2. Stamp or print tags or labels to correspond with markings on the Contract Drawings or accepted Shop Drawings, or mark so that feeder, cable or conductor may be readily identified. Tags on conductors at switches, receptacles, motor control panels, wireways, and junction boxes shall bear the circuit number of the conductor as it appears in the circuit directory. Mark conductors in motor control panels with the terminal number.
3. If suspended type tags are provided, design tie tags with slip-free plastic cable lacing unit or design for attachment by nylon bundling straps.

F. Cable Supports and Fasteners: Design for use with channel inserts.

G. Conductor Bundling Straps

1. Formed from self-extinguishing nylon having a temperature range of minus 65°F to plus 250°F.
2. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.
3. Make wire and cable ties for installation outdoors and in exposed locations of ultraviolet resistant nylon material.

H. Splice and Terminal Connectors

1. Design termination fittings for use with the cable furnished, NEMA Standard, and UL approved.
2. Termination and splice fittings for No. 10 and smaller conductors: Screw on, spring pressure-type copper connectors with nonflammable, self-extinguishing insulation of temperature rating equal to that of cable being connected. Terminals to provide a metal insulation grip on the conductor for strain relief.
3. Termination and splice fittings for No. 8 and larger conductors: Tool-applied compression connectors of material and design compatible with the conductors for which they are used.
4. Terminal connectors for conductors Size No. 4/0 and larger: Long-barrel, double compression type, and furnished with two bolting holes in the pad.

I. Insulating Material for Splices and Terminations

1. Of the type approved by the Engineer for the particular use, location and voltage, 3/4 inch nominal width.
2. Plastic electrical insulating tape for general use: Vinyl plastic with rubber-based pressure-sensitive adhesive. Pliable at temperature of minus 18°C to 105°C. When tested in accordance with ASTM D 3005, the tape shall have the following minimum properties:
 - a. Thickness: 7 mils.

- b. Breaking Strength: 15 pounds per inch.
 - c. Elongation: 200%.
 - d. Dielectric Strength: 10,000 volts/mil
 - e. Insulation Resistance (Direct method of electrolytic corrosion): 1,000,000 megohms.
- 3. Rubber electrical insulating tape for protective overwrapping: Silicone rubber with a silicone pressure-sensitive adhesive. When tested in accordance with ASTM D1000, the tape shall have the following minimum properties:
 - a. Thickness; 15 mils.
 - b. Tensile Strength: 11 pounds per inch.
 - c. Elongation: 525%.
 - d. Dielectric Strength: 13,000 volts
 - e. Insulation Resistance (Indirect Method of Electrolytic corrosion): 1,000,000 megohms.
- 4. Arcproof Tape: Flexible, conformable organic fabric, coated one side with a flame-retardant flexible elastomer-self-extinguishing, with the following minimum properties:
 - a. Thickness, ASTM D1000: 55 mils.
 - b. Tensile strength, ASTM D1682; 50 pounds per inch.
 - c. Thermal conductivity, ASTM D1518; 0.478 btu/hour/square foot/degrees F.
 - d. Electrical Arc Resistance: Withstand 200 ampere arc for 40 seconds.
- 5. Mark each tape package to indicate shelf-life expiration date.
- 6. Glass Cloth Electrical Insulating Tape (for use with arcproof tape): Woven glass fabric; when tested in accordance with ASTM D1000, the tape shall have the following minimum properties:
 - a. Thickness: 7 mils
 - b. Breaking Strength: 170 pounds per inch.
 - c. Elongation: 5%.
 - d. Dielectric Breakdown: 2,500 volts.
 - e. Insulation Resistance (Indirect Method of Electrolytic Corrosion): 5,000 megohms.

0.14 WIRING DEVICES

- A.** General. Wiring devices include switches, receptacles and special outlets installed in raceway or conduit boxes, complete with cover plates.
- B.** Switches
 - 1. AC tumbler-toggle switches: Meeting minimum requirements of UL 20 and further requirements herein specified and of specification grade, heavy duty, of the type indicated.
 - 2. Provide switches that operate in any position and are fully enclosed with entire body and cover of molded phenolic, urea or melamine. Do not use fiber, paper or similar insulating material for body or cover.

3. Equip switches with metal mounting yoke with plaster ears, insulated from the mechanism and fastened to the switch body by bolts, screws, rivets or other substantial means that meet test requirements.
4. Provide a green-colored equipment grounding screw on the yoke.
5. Provide the section of the yoke normally intended to bear on the surface outside the box with a minimum over-all dimension of 3/4 inch, measured at right angles to the longitudinal axis of the yoke.
6. Make switch contacts between silver or silver alloys.
7. Switches shall be back and side wired with terminals of screw or combination screw-clamp type.
8. Terminal Screws: No. 8 or larger, captive or terminal type.
9. Provide access holes for back wiring.
10. Wiring terminals capable of receiving and holding proper wire sizes as shown below:

Switch Rating	Wire Size, AWG No.
20 amperes	12 and 14
30 amperes	10

- C.** Wall switches: Tumbler type, totally enclosed, heavy duty, in accordance with NEMA WD 1.
- D.** Switches for use on incandescent or fluorescent lighting circuits: Fully rated 20 amperes at 120 or 277 volts, as indicated. Actual connected lamp wattage not to exceed the following:

Switch Rating at 120-277 Volts	Maximum Wattage Allowed	
	120 Volts	277 Volts
20 amperes	1,400	3,000

- E.** Switches controlling outlets other than lighting, such as motors less than 1/4 horsepower may be specification grade, flush type, AC - DC, T-rated 20 ampere, 125 volts. Switches controlling straight resistance loads may be snap switches as specified herein, of the proper rating up to 30 amperes at 120-277 volts.
- F.** Provide ac 120-277 volt snap switches capable of withstanding tests as outlined in NEMA WD 1, Paragraphs WD 1-2.04, WD 1-2.05A, WD 1-2.05C, WD 1-2.05E2, WD 1-2.05F2, and WD 1-2.05G. If requested by the Engineer, submit satisfactory evidence that the types of switches proposed have satisfactorily withstood these tests.

0.15 RECEPTACLES AND PLUGS

- A.** Configuration and requirements for connector and outlet receptacles; UL 498 and NEMA WD 1 for heavy duty general use type.
- B.** Receptacles: Fire-resistant nonabsorptive, hotmolded phenolic composition or equal bodies and bases with metal plaster ears integral with supporting member.
- C.** Type: Flush type, except where otherwise indicated.
 - 1. Wall receptacles; Single or duplex as shown on the Contract Drawings.
 - 2. Provide receptacles and plugs (caps) with light-colored terminal facilities for neutral connections, amber or brass colored for phase conductor connections, and green-colored hexagonal machine screws for the equipment grounding conductor or connections.
 - 3. All contracts of the receptacles, including the grounding contract: Double grip bronze type with spring steel backup clips so that both sides of each male prong of the plug will be in firm contact.
 - 4. Provide all receptacles with self-grounding clip or mounting strap screws.
 - 5. Ground fault circuit interrupter duplex receptacles shall be 120 volt, 60 Hz, 15 ampere with built-in test, reset buttons, and ground fault tripped indication. They shall interrupt the circuit within 1/30th of a second on a 5 milliampere earth leakage current. They shall be designed for end of run installation or with provisions for feeding through to protect other outlets on the circuit. Maximum circuit capacity for the latter shall be 20 amperes. The receptacles shall be furnished with necessary wire connectors, clips, mounting scores and instruction.
- D.** Clock Receptacles
 - 1. Receptacles for clocks are not required for clocks operating on less than fifty volts, and flush-mounted clocks (inserted type).
 - 2. Provide receptacles for clocks conforming to NEMA 5-15R, recessed so that male cap will be flush with the wall to permit the clock to cover the outlet.
 - 3. Provide plates, including finishes, as specified for cover plates, adapted to the recessed receptacles and with substantial hooks to support the clocks.
 - 4. Receptacles for surface-mounted clocks connected to the building 120-volt electrical system: As indicated.
 - 5. Where clock receptacles are shown on the Contract Drawings or specified, furnish the grounded type and provide with a ground jumper.

0.16 COVER PLATES

- A.** Provide cover plates for each switch, receptacle, and special purpose outlet.
- B.** Use multi-gang plates for multi-gang boxes.
- C.** Unless otherwise indicated, use cover plates conforming to FS W-P-455.
- D.** Provide and install cover plates of brushed stainless steel in ancillary spaces, mechanical rooms, fan rooms, wire closets, AC switchboard rooms, traction substations, and all unfinished areas.
- E.** In public areas provide cover plates fabricated of corrosion-resistant steel, 18% chromium, 8% nickel with baked porcelain enamel bronze finish.
- F.** For special purpose outlets commercially produced using special material, configuration, and size, use plate of brushed stainless steel and of a design for the particular application.
- G.** Where plates of material and finish herein specified are not available commercially for these special purpose outlets, plates commercially available and suitable for enameling to match adjacent surface will be acceptable.
- H.** Use stainless steel cover plates of 0.040 thickness for flush devices.

0.17 DISCONNECTION DEVICES

- A.** Safety Switch Type Disconnecting Devices: Enclosed, conforming to UL Standards and the following:
 - 1. Motor Circuit Switches (600 Volts AC):
 - a. Furnish motor circuits with a separately mounted disconnect switch where required within sight of the motor.
 - b. Switch: HP rated, UL listed, quick make quick break, full cover interlock and indicator handle, conforming to FS W-S-865 for heavy duty switches.
 - c. Enclosure Type: As indicated.
 - d. Furnished handle mechanism with continuous engagement of the switch handle whether the door is open or closed, and is pad-lockable in the OFF and ON position.
 - 2. Heavy Duty Safety Switches (240 Volts AC):
 - a. Furnish heavy-duty safety switches having electrical characteristics, ratings, and modifications indicated.
 - b. Furnish switches with NEMA 12 General Purpose Enclosures, unless otherwise indicated, and with metal nameplates, front cover mounted, containing a permanent record of switch type, catalog number, and HP ratings.

- c. Furnish handle with visible blades; reinforced fuse clips; nontearable, positive, quick make-quick break mechanism, and which is pad-lockable in the OFF and ON position.
 - d. Furnish switches meeting NEMA KS 1 requirements.
- 3. Heavy Duty Safety Switches (600 Volts AC):
 - a. Furnish heavy-duty safety switches having electrical characteristics, ratings, and modifications shown on the Contract Drawings.
 - b. Furnish all switches with NEMA 12 General Purpose Enclosures, unless otherwise indicated, meeting NEMA KS 1 requirements.

PART 3 - EXECUTION

0.1 GENERAL

- A.** Install all items in their proper locations as shown on the Contract Drawings, rigid and secure, plumb and level, and in true alignment with related and adjoining work. Do not weld electrical materials for attachment or support.
- B.** Furnish anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the job site to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.
- C.** Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts and angles as required to set and connect rigidly the work.
- D.** Control erection tolerance requirements to not impair the strength, safety, serviceability, or appearance of the installations, as approved by the Engineer. Determine exact location of conduit. Route all conduit parallel to building lines.
- E.** The trade size, type and general routing and location of conduits, raceways, and boxes shall be as indicated.
- F.** Install exposed conduit so as to avoid conflicts with other work. Install horizontal raceway close to the ceiling or ceiling beams, and above water or other piping whenever possible.
- G.** Install individual conductors in conduits, raceways, cable trays, ducts, and trenches and multiple-conductor sheathed cables as shown on the Contract Drawings to complete the wiring systems.
- H.** Install switches, receptacles, special purpose outlets, and cover plates complete in a neat manner in accordance with the NEC and local electrical codes.

0.2 CONDUIT AND FITTINGS

A. Metallic Electrical Conduit

1. Install metallic conduit in accordance with the NEC and as indicated. Prevent concrete and other materials from obstructing the conduit. Pack all outlet, pull and junction boxes with paper prior to pouring concrete ends of embedded conduit. Do not use conduit smaller than 3/4-inch diameter.
2. Make all conduit bends in accordance with the NEC, with not more than 3 bends per run. Where more than 3 bends are required in a particular run, install pull boxes as required to facilitate pulling conductors.
3. Unless otherwise indicated, terminate metallic conduit installed for future extension with flush couplings set to finished floor level.
4. Provide metallic numbering tags indicating the conduit number on the end of conduit. Identify train control and communication conduit as indicated.
5. Properly support conduit to be embedded to maintain correct location and spacing during concreting operations. If necessary, provide suitable metal supports for this purpose.
6. Install conduit so that any moisture collecting in the conduit will be drained to the nearest outlet or pull box.
7. Whenever exposed or buried conduit passes through an expansion or contraction joint in the structure, install the conduit at right angles to the joint, and provide an approved conduit expansion joint at the joint. Paint the conduit with an approved bituminous compound for one foot on each side of the expansion couplings.
8. Provide expansion joints in conduit runs where required to compensate for thermal expansion.
9. Rod and swab embedded conduit after installation to remove foreign matter, which may have worked in at the joints. If obstructions are encountered which cannot be removed, or if any conditions exist which may result in damage to wires and cables pulled through the conduit, install new conduit at no additional expense to the Authority.
10. After the conduit has been rodded and swabbed, repack boxes and protect conduit ends to prevent any foreign material from entering the conduit.
11. Where metallic conduit is exposed to different temperatures, seal the conduit to prevent condensation and passage of air from one area to the other.
12. Use only conduits that are electrically and mechanically continuous and connect to the structure ground system. Secure continuous ground by bonding where required.
13. Apply conductive antisieze compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Terminate the conduit in appropriate boxes at all motors, switches, outlets, and junction points.
14. When field cutting of conduit is required, thread and ream the conduit to remove any rough edges. Where a conduit enters a box or other

- fitting, provide a bushing to protect the wire from abrasion. Provide insulation type bushings and double locknuts on ends of rigid conduits terminating at steel boxes, panelboards, cabinets, motor starting equipment, and similar enclosures.
15. Support individual horizontal conduits not larger than 1-1/2 inches diameter by means of one-hole pipe straps with back spacers or individual pipe hangers.
 16. Space conduits installed against concrete surfaces away from the surface by clamp backs or other approved means.
 17. Support individual horizontal conduits larger than 1-1/2 inches diameter by individual pipe hangers.
 18. In dry locations, spring steel fasteners, clips, or clamps specifically designed for supporting exposed single conduits may be used in lieu of pipe straps or pipe hangers.
 19. Hanger rods used in connection with spring steel fasteners, clips, and clamps shall be either 1/4-inch diameter galvanized steel rods or, if concealed above a suspended ceiling, galvanized perforated steel strapping. Do not use wire for support of conduit.
 20. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the pipe hanger or channel insert member by a U-bolt, one-hole strap, or other specially designed and approved fastener suitable for use with the pipe hangers or channel inserts.
 21. Space supports not over 10 feet on centers for vertical conduits spanning open areas. Securely anchor conduit at each end and run so as not to interfere with the installation and operation of equipment at the location.
 22. Support conduits and raceways above suspended ceilings from either the floor construction above or from the main ceiling support members, using the applicable method specified herein.
 23. Install liquid-tight flexible metal conduit so that liquids tend to run off the surface and not drain toward fittings. Provide sufficient slack to reduce the effects of vibration. Running threads are not acceptable. Where necessary for connecting conduits, use right and left hand couplings.

B. Non-Metallic Electrical Conduit

1. Non-metallic electrical conduit includes polyvinyl chloride (PVC) and asbestos cement conduit.
2. Cap or plug the ends of embedded conduit to prevent concrete and other materials from obstructing the conduit.
3. Sandpaper joints in PVC conduit to remove all burrs, clean and dry the joints, and brush with a solvent cement acceptable to the manufacturer before installing.
4. Properly support conduits to maintain the correct location and spacing during concreting operations and, if necessary, provide suitable plastic supports and spacers for this purpose.
5. Wherever buried non-metallic conduit passes through an expansion or contraction joint, or where required to compensate for thermal

expansion and contraction, provide a conduit expansion joint. Install the conduit to cross the joint at right angles. In areas of floating slabs, install horizontal runs of conduit beneath the floating slab. Conduit shall pass through the floating slab only where required to terminate in a vertical direction as shown on the Contract Drawings.

C. Pull Wires

1. Use nylon pull wires of tensile strength not less than 240 pounds in each conduit and duct, leave pull wires in ducts and conduit after cleaning.
2. No splices in pull wire will be allowed.
3. Leave ample slack length at each end of pull wire.

D. Filling of Openings. Wherever slots, sleeves, or other openings are provided in floors or walls for the passage of raceways, including bus ducts, fill such openings as follows:

1. Use fire-resistive filling material for openings similar to the material of the floor, wall or ceiling being penetrated, and finish to prevent passage of water, smoke, and fumes.
2. Where conduits passing through openings are exposed in finished rooms, use filling material that matches, and is flush with, the adjoining finished floor, ceiling or wall.

0.3 INSERTS

A. Channel Inserts. Install embedded channel inserts with the slotted face flush with the finished concrete surface.

B. Spot Inserts

1. Install with the insert face flush with the finished concrete surface, firmly embedded, with no evidence of movement.
2. Test selected inserts, as required by the Engineer, by suspension of 800 pounds of weight from the insert. If there is evidence of failure, replace the inserts in a manner satisfactory to the Engineer.

0.4 SURFACE METAL RACEWAYS

A. Securely ground surface metal raceways to outlet boxes or to backplates and fixtures by means of bolts, screws or other approved means and as specified in Section 16450 - GROUNDING.

B. Install surface metal raceways where indicated, in accordance with the NEC. Use fittings and accessories designed for the raceway.

0.5 OUTLET, JUNCTION AND PULL BOXES

A. Outlet Boxes

1. Unless otherwise indicated, flush mount outlet boxes with the front edges of the boxes or plaster covers attached thereto flush with the finished wall or ceiling.
2. Mount boxes so that the long axis of the devices will be vertical, unless otherwise indicated.
3. Locate conduit boxes and conduit box knockouts so as not to interfere with the reinforcing steel.
4. Unless otherwise specified, provide boxes in plastered walls and ceilings with plaster covers. Do not install these covers until the finish plaster line is determined for the particular location.
5. The mounting height indicated for a wall-mounted outlet box shall be construed to mean the height from the finished floor to the horizontal centerline of the cover plate.
6. Mount outlet boxes for switches and receptacles located on columns and pilasters so as not to interfere with installation of partitions.
7. Install boxes located near doors on the lock sides, even where the symbols appear on the hinge sides on the Contract Drawings, unless other locations are approved by the Engineer.

B. Junction and Pull Boxes

1. Install so that covers are readily accessible after completion of the installation.
2. Do not install boxes above suspended ceilings, except where the ceiling is of the removable type or where definite provisions are made for access to each box.

C. Boxes Set in Concrete

1. Adequately support boxes to prevent movement during placement of concrete.
2. Unused nailing holes or other holes in the side or bottom of the boxes will not be permitted.
3. After installation, clean boxes placed in concrete.

0.6 CABLE TRAYS

- A.** Install as shown on the Contract Drawings and in accordance with NEC Article 318 using approved fittings and adequately supporting the complete system.
- B.** Provide anti-sway brackets on all horizontal tray assemblies where necessary.

- C.** Connect each isolated cable tray system or the entire tray system to the building equipment grounding system with a green insulated conductor in accordance with the NEC.
- D.** Base size determination on the largest power conductor in the rack.
 - 1. Minimum size: No. 6
 - 2. Maximum size: 4/0 copper

0.7 UNDERFLOOR DUCTS AND FITTINGS

- A.** Install as shown on the Contract Drawings.
- B.** Accurately align and level the ducts with the top of inserts 1/8 inch below the finished concrete floor.
- C.** Hold ducts in place during pouring of concrete by use of duct support fitting designed for the duct used, spaced at five-foot intervals. Carefully level all boxes, with the tops flush with the finish floor.
- D.** Install appropriate insert markers in the last insert at all dead ends, on each side of partitions, and first insert adjacent to junction box to indicate high and low voltage services.
- E.** Seal duct installation watertight with an approved sealing compound.

0.8 WIRING

A. General

- 1. Furnish wires and cables to the site in unbroken standard coils or reels, to which shall be attached a tag bearing the manufacturer's name, trade name of the wire, and the UL label for 600 volt wire and cable.
- 2. Provide all wiring complete as indicted. Provide ample slack wire for motor loops, service connections and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.
- 3. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impracticable, and shorter radii are permitted by the NEC and NEMA Standard WC 7, Appendix N.
- 4. Neatly and securely bundle cable conductors located in branch circuit panelboards, cabinets, control boards, switchboards and motor control centers and pull boxes. Use nylon bundling straps.

B. Wire Pulling

1. Install wire and cable in conduit as indicated. Do not pull wiring into any conduit until conduits and outlets have been thoroughly cleaned and swabbed to remove water and debris. Do not use block or tackle or other mechanical means in pulling conductors smaller than No. 2 AWG in raceways.
 2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer, and as approved by the Engineer.
 3. Use masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.
 4. Pull together all cables to be installed in a single conduit.
- C. Cable Supports.** Install cable supports for vertical feeders in accordance with the NEC.
- D. Splices and Terminations**
1. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets. Splices in conduit or raceway will not be permitted. Make splices by means of compression type connectors, and cover with tape to an insulation level equal to that of the cable.
 2. Use positive type connector installation tools as recommended by the manufacturer.
 3. Mechanical hand tools, with dies for each conductor size, recommended by the manufacturer, may be used on conductor sizes through No. 4/0.
 4. For conductor sizes larger than No. 4/0, use hydraulic tools with hexagonal or circumferential installing dies for each conductor size, as recommended by the manufacturer.
 5. For inspection purposes, clearly mark die numbers on the installed connectors.
 6. Before installation, apply anti-corrosion electrical joint compound to conductors and terminal bolting pads.

0.9 WIRING DEVICES

- A.** Locate switches four feet above finished floor, except as otherwise indicated.
- B.** Attach receptacles rigidly to outlet box by means of two screws.
- C.** Wire duplex receptacles, where so indicated, so that one unit of the duplex may be controlled by a wall switch and the other unit remain continuously energized.
- D.** For exterior locations, mount receptacles in watertight cast type outlet boxes with threaded hubs or bosses and equipped with gasketed cover and captive cap of the screw or twist type.

- E. Provide equipment permanently connected to exterior receptacles, or in areas subject to spray or hose cleaning, with watertight male plugs to suit. Such receptacles shall be of the ground fault circuit interrupter type, as specified herein.
- F. Furnish one matching plug with each receptacle, as indicated, installed in the work.

PART 4 - MEASUREMENT AND PAYMENT

0.1 GENERAL

- A. No separate measurement or payment will be made for work required under this Section. All costs in connection therewith shall be considered incidental to the item or items of work to which they pertain.

END OF SECTION